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GUAM ENVIRONMENTAL PROTECTION AGENCY

POST OFFICE BOX 2999 AGANA, GUAM 96910 TELEPHONE: 646-8863/64/65

OCT 8 1981

SDMS Doc ID 2003507

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EPA. REGION IX
OCT 15 10 40 AM '81

Mr. Jake MacKenzie
Superfund Coordinator
U.S. Environmental Protection
Agency, Region IX
215 Fremont Street
San Francisco, California 94105

Dear Mr. MacKenzie:

Please find enclosed the completed Mitre Model for the Ordot Landfill. As mentioned in the worksheets Surface Water is the route of major concern. The Guam EPA laboratory recently produced some interesting numbers with respect to high heavy metal and pesticide content in surface waters bordering the landfill. The high pesticide count is viewed as a serious matter so the Guam EPA is in the process of producing additional data to validate our analysis. We will forward the validated findings to you as soon as they are available.

The Guam EPA has a number of questions with respect to our Superfund relationship. What is our status with respect to Superfund consideration? How does Guam fit into the National Contingency Plan? What is our relationship with the Regional Response Team? Who is the On-scene-Coordinator for Guam? Is our original expression of Guam being a "special case" due to our unique island environment and unaddressed hazardous waste disposal problem still being considered? When will training and guidance sessions be offered to Guam EPA staff and will we negotiate a State/EPA Cooperative Agreement with respect to our Superfund relationship?

Your timely response to these inquiries is appreciated, please contact Dan Crytser with any response or comments.

Sincerely yours,

Ricardo C. Duenas

RICARDO C. DUENAS
Administrator

Enclosure

APPENDIX E
MODEL WORKSHEETS

Site Name: Ordot Landfill

Location: San Carlos Street, Ordot, Guam

EPA Region: Region IX

Person(s) in Charge of the Site: J. Gutierrez - Director
Government of Guam
Department of Public Works

Name of Reviewer: Dan Crytser

Site Overall Score: 30.2

General Description of the Site:

(For example landfill, surface impoundment, pile, container, types of wastes; location of the site, contamination route of major concern, types of information needed for rating, agency action, etc.)

This site is a Government of Guam operated municipal landfill. It is registered on the RCRA Open Dump Inventory. The contamination route of major concern is surface water. Due to quanity of precipitation, permeability and lack of leachate control system it is believed that toxic leachates including pesticides are contaminating nearby surface waters.

ROUTE - GROUND WATER						
Rating Factor	Basis of Information	Site Rating (Circle one)		Multiplier	Site Score	Maximum Possible Score
① OBSERVED RELEASE						
Measured Level or Evidence of Release		0	45	1	0	45
If the site score is zero, go to step ② otherwise, go to step ⑤						
② ROUTE CHARACTERISTICS[1]						
Depth to Aquifer of Concern		0 1 2 3		2	0	6
Net Precipitation		0 1 2 3		1	3	3
Permeability of Unsaturated Zone		0 1 2 3		2	6	6
				Subtotal	9	15

[1]A rating of zero should be entered when data is unavailable to rate an additive factor. A rating of 1 should be entered when data is unavailable to rate a multiplicative category such as the waste quantity or containment. A total of 5% missing data. (For the entire site is allowed when rating a site.)

ROUTE - GROUND WATER

Rating Factor	Basis of Information	Site Rating (Circle one)	Multiplier	Site Score	Maximum Possible Score
3 CONTAINMENT [1,2]					
Containment		0 1 2 3	1	3	3
4 POTENTIAL FOR RELEASE					
Multiply site score from 2 by site score from 3. The product is site rating for this route.		27	1	27	45
5 RELEASE					
Enter site score from 1 or 4				27	45
6 WASTE CHARACTERISTICS [1,3]					
Physical State		0 1 2 3	1	3	3
Persistence		0 1 2 3	2	6	6
Toxicity/Infectiousness		0 1 2 3	2	6	6
			Subtotal	15	15
7 HAZARDOUS WASTE QUANTITY [1]					
Total Waste Quantity (by Superfund definition) excluding waste that is totally contained		0 1 2 3 4 5	1	1	5

[2] If the site has more than one type of containment (e.g., surface impoundment, landfill, containers), consider all cases separately and enter the score from the worst case.

[3] Rate the five most hazardous wastes. Select the one with the highest subtotal score and enter that score.

ROUTE - GROUND WATER					
Rating Factor	Basis of Information	Site Rating (Circle one)	Multi-plier	Site Score	Maximum Possible Score
8 TARGETS[1]					
Ground water use		0 1 2 3	4	8	12
Distance to nearest drinking water well		0 1 2 3	4	12	12
Population served by ground water within 3 mile radius		0 1 2 3 4 5	8	16	40
			Subtotal	36	64
9 GROUND WATER ROUTE SUBTOTAL					
A. Multiply 5 x 6 x 7 x 8				14580	216,000
B. Multiply A by normalization factor of 0.45 and divide by 1,000			0.45	6.56	97.2

Route Subtotal (B) 6.6

ROUTE - SURFACE WATER

Rating Factor	Basis of Information	Site Rating (Circle One)	Multiplier	Site Score	Maximum Possible Score
1 OBSERVED RELEASE (ref SW 1)					
Measured level or evidence of release		0 45 ✓	1	45	45
If the site score is zero, go to step 2 otherwise, go to step 5					
2 ROUTE CHARACTERISTICS[1] (ref SW 2)					
Site Slope and Terrain		0 1 2 3	1		3
1 Year 24 Hour Rainfall		0 1 2 3	1		3
Distance to Surface Water		0 1 2 3	1		3
Flood Potential		0 1 2 3	2		6
			Subtotal		15
3 CONTAINMENT[1,2] (ref SW 3)					
Containment		0 1 2 3	1		3
4 POTENTIAL FOR RELEASE					
Multiply site score from 2 by site score from 3 The product is site rating for this route.			1		45
5 RELEASE					
Enter site score from 1 or 4				45	45
6 WASTE CHARACTERISTICS[1,3] (ref SW 4)					
Physical State		0 1 2 3 ✓	1	3	3
Toxicity / Infectiousness		0 1 2 3 ✓	2	6	6
Persistence		0 1 2 3 ✓	2	6	6
			Subtotal	15	15
7 HAZARDOUS WASTE QUANTITY[1] (ref SW 5)					
Total Waste Quantity		0 1 ✓ 2 3 4 5	1	1	5
(by Superfund definition) excluding waste that is totally contained					
8 TARGETS[1] (ref SW 5)					
Surface Water Use		0 1 2 ✓ 3	3	6	9
Critical Habitats		0 1 2 ✓ 3	2	6	6
Population Served by Surface Water With Water Intake Within 3 Miles Downstream From Site		0 1 2 3 ✓ 4 5	6	18	30
			Subtotal	30	45
9 SURFACE WATER ROUTE SUBTOTAL					
A. Multiply 5 × 6 × 7 × 8				20,250	151,375
B. Multiply (A.) by normalization factor of 0.64 and divide by 1,000			0.64	13.0 (S) Route Subtotal	97.2

ROUTE - FIRE AND EXPLOSION

Rating Factor	Basis of Information	Site Rating (Circle One)	Multiplier	Site Score	Maximum Possible Score
1 ROUTE CHARACTERISTICS' (ref FE 1)					
Ignition Source		0 15	1	15	15
2 CONTAINMENT[1,2] (ref FE 2)					
Containment		0 3	1	3	3
3 POTENTIAL FOR RELEASE					
Multiply site score from 1 by site score from 2. The product is site rating for this route			1	45	45
4 RELEASE					
Enter site score from 3				45	45
5 WASTE CHARACTERISTICS[1,3] (ref FE 3)					
Ignitability		0 1 2 3		0	3
Reactivity		0 1 2 3	1	1	3
Incompatibility		0 1 2 3		2	3
			Subtotal	3	9
6 HAZARDOUS WASTE QUANTITY[1] (ref FE 4)					
Total Waste Quantity		0 1 2 3 4 5	1	1	5
(by Superfund definition) excluding waste that is totally contained					
7 TARGETS[1,2] (ref FE 5)					
Distance to Nearest Population		0 1 2 3 4 5	1	3	5
Distance to Nearest Off Site Building		0 1 2 3	1	2	3
Distance to Environmentally Sensitive Area		0 1 2 3	1	3	3
Land Use		0 1 2 3	1	3	3
Population Within 2 Mile Radius		0 1 2 3 4 5	1	3	5
Number of Buildings Within 2 Mile Radius		0 1 2 3 4 5	1	3	5
			Subtotal	17	24
8 FIRE AND EXPLOSION ROUTE SUBTOTAL					
A. Multiply 4 × 5 × 6 × 7				2295	48 600
B. Multiply (A) by normalization factor of 2.0 and divide by 1 000			2.0	4.6 (B) Route Subtotal	97.2

*The fire and explosion route will be considered only if a state or local fire marshal has certified that the site represents a significant fire and explosion threat to the public and to sensitive environment. However, any demonstrated fire and explosion threat based on field observation (e.g., explosivity meter readings) will also be considered as sufficient evidence.

10	AGGREGATE SITE RATING		
Route	Route Subtotal from 6, 8 or 9	Route Subtotal Squared	Maximum Possible Score
Ground Water	6.6	43.6	$(97.2)^2$ = 9447.34
Surface Water	13.0	169.0	$(97.2)^2$ = 9447 84
Air	0	0	$(97.2)^2$ = 3447.84
Fire and Explosion	4.6	21.2	$(97.2)^2$ = 9447.84
Direct Contact	63.8	4070.4	$(97.2)^2$ = 9447.84
Sum		4304.2	47239.2
Square root of Sum		65.6	217.35
Overall Score* $= \left(\frac{\sqrt{sum} \times 100}{217.35}\right)$		30.2	100

*The overall score will be between 0 and 100. The Maximum Overall Score for a Site With Only One Exposure Route Is 44.7.

3 PATHWAY ORAOT Score

10	AGGREGATE SITE RATING		
Route	Route Subtotal from 6 or 9	Route Subtotal Squared	Maximum Possible Score
Ground Water	6.0	36	$(97.2)^2 = 9447.84$
Surface Water	13.0	169	$(97.2)^2 = 9447.84$
Air	0	0	$(97.2)^2 = 9447.84$
Sum		205	28,343.52
Square Root of Sum		14.3	168.36
Overall Score* =	$\frac{\text{sum} \times 100}{168.36}$	8.5	100

FIRE AND EXPLOSION	
Route Subtotal from 8 4.6 - MAY be incorrect d/r to non-ignitable	Maximum Possible Score
	97.2
Adjusted Score = $\frac{\text{Route Subtotal} \times 100}{97.2}$ = 4.7	

DIRECT CONTACT	
Route Subtotal from 8 63.8	Maximum Possible Score
	97.2
Adjusted Score = $\frac{\text{Route Subtotal} \times 100}{97.2}$ 65.6	

*The overall and adjusted scores will be between 0 and 100. The maximum overall score for a site with only one exposure route is 57.7.

APPENDIX E
MODEL WORKSHEETS

Site Name: ORDOT LANDFILL

Location: GUAM

EPA Region:

Person(s) in Charge of the Site:

Name of Reviewer: LERY

Site Overall Score: MITRE 8.9, F/E 4.7, DC 75

General Description of the Site: MITRE SCORE IS CONSERVATIVE ESPECIALLY WITH REGARD TO QUANTITY

(For example: landfill, surface impoundment, pile, container; types of wastes; location of the site; contamination route of major concern; types of information needed for rating; agency action, etc.)

ROUTE - SURFACE WATER

Rating Factor	Basis of Information	Site Rating (Circle One)	Multiplier	Site Score	Maximum Possible Score
1 OBSERVED RELEASE (ref SW 1)					
Measured level or evidence of release	based on pesticide and metal runoff	0 45	1	45	45
If the site score is zero, go to step 2 otherwise, go to step 5					
2 ROUTE CHARACTERISTICS[1] (ref SW 2)					
Site Slope and Terrain		0 1 2 3	1		3
1 Year 24 Hour Rainfall		0 1 2 3	1		3
Distance to Surface Water		0 1 2 3	1		3
Flood Potential		0 1 2 3	2		6
			Subtotal		15
3 CONTAINMENT[1,2] (ref SW 3)					
Containment		0 1 2 3	1		3
4 POTENTIAL FOR RELEASE					
Multiply site score from 2 by site score from 3. The product is site rating for this route.			1		45
5 RELEASE					
Enter site score from 1 or 4				45	45
6 WASTE CHARACTERISTICS[1,3] (ref SW 4)					
Physical State	estimates based on Ordot being	0 1 2 3	1	3	3
Toxicity, Infectiousness	open as an open dump for 20 years	0 1 2 3	2	6	6
Persistence	and known pesticide and metal contamination	0 1 2 3	2	6	6
			Subtotal	15	15
7 HAZARDOUS WASTE QUANTITY[1] (ref SW 5)					
Total Waste Quantity	UNKNOWN	0 1 2 3 4 5	1	1	5
(by Superfund definition) excluding waste that is totally contained					
8 TARGETS[1] (ref SW 6)					
Surface Water Use	recreation, irrigation	0 1 2 3	3	6	9
Critical Habitats		0 1 2 3	2	4	6
Population Served by Surface Water With Water Intake Within 3 Miles Downstream From Site	CONSERVATIVE EST. based on NEARBY VILLAGE POP of 780	0 1 2 3 4 5	6	18	30
			Subtotal	28	45
9 SURFACE WATER ROUTE SUBTOTAL					
A. Multiply 5 x 6 x 7 x 8	45 · 15 · 1 · 28			18900	151,875
B. Multiply (A.) by normalization factor of 0.64 and divide by 1,000			0.64	12.1 (B.) Route Subtotal	97.2

Nor re-scored, GEPA data used

ROUTE - FIRE AND EXPLOSION

Rating Factor	Basis of Information	Site Rating (Circle One)	Multiplier	Site Score	Maximum Possible Score
1 ROUTE CHARACTERISTICS* (ref FE 1)					
Ignition Source		0 3	1	15	15
2 CONTAINMENT[1,2] (ref FE 2)					
Containment		0 3	1	3	3
3 POTENTIAL FOR RELEASE					
Multiply site score from 1 by site score from 2. The product is site rating for this route		-	1	45	45
4 RELEASE					
Enter site score from 3				45	45
5 WASTE CHARACTERISTICS[1,3] (ref FE 3)					
Ignitability		0 1 2 3	1	0	3
Reactivity		0 1 2 3	1	1	3
Incompatibility		0 1 2 3	1	2	3
			Subtotal	3	9
6 HAZARDOUS WASTE QUANTITY[1] (ref FE 4)					
Total Waste Quantity	UNKNOWN	0 1 2 3 4 5	1	1	5
by Superfund definition excluding waste that is totally contained.					
7 TARGETS[1,2] (ref FE 5)					
Distance to Nearest Population		0 1 2 3 4 5	1	3	5
Distance to Nearest Off Site Building		0 1 2 3	1	2	3
Distance to Environmentally Sensitive Area		0 1 2 3	1	3	3
Land Use		0 1 2 3	1	3	3
Population Within 2 Mile Radius		0 1 2 3 4 5	1	3	5
Number of Buildings Within 2 Mile Radius		0 1 2 3 4 5	1	3	5
			Subtotal	17	24
8 FIRE AND EXPLOSION ROUTE SUBTOTAL					
A. Multiply 4 x 5 x 6 x 7	45 · 3 · 1 · 17			--	48,600
B. Multiply (A) by normalization factor of 2.0 and divide by 1,000			2.0	4.6 (B) Route Subtotal	97.2

*The fire and explosion route will be considered only if a state or local fire marshall has certified that the site represents a significant fire and explosion threat to the public and to sensitive environment. However, any demonstrated fire and explosion threat based on field observation (e.g., explosivity meter readings) will also be considered as sufficient evidence.

10

AGGREGATE SITE RATING

Route	Route Subtotal from 6 or 9	Route Subtotal Squared	Maximum Possible Score
Ground Water	9.1	82.81	$(97.2)^2$ = 9447.84
Surface Water	12.1	146.41	$(97.2)^2$ = 9447.84
Air	0	~~228.2~~	$(97.2)^2$ = 9447.84
Sum		228.2	28,343.52
Square Root of Sum		15.1	168.36
Overall Score* = $\frac{\text{sum} \times 100}{168.36}$		8.9	100

FIRE AND EXPLOSION

Route Subtotal from 8	Maximum Possible Score
	97.2
Adjusted Score = $\frac{\text{Route Subtotal} \times 100}{97.2}$	4.7

DIRECT CONTACT

Route Subtotal from 8	Maximum Possible Score
	97.2
Adjusted Score = $\frac{\text{Route Subtotal} \times 100}{97.2}$	75

*The overall and adjusted scores will be between 0 and 100. The maximum overall score for a site with only one exposure route is 57.7.

MITRE MODEL (SUPERFUND) VERIFICATION

Prepared by

DAN CRYTSER
Director of the Solid
and Hazardous Waste
Management Program

At the outset it must be stated that the route of major concern is surface water. This does not preclude the possibility of groundwater contamination but due to the location of the landfill in relation to the potable water supply harmful groundwater contamination by leachate from the landfill seems unlikely. Unfortunately, there are no monitoring wells in the landfill.

However surface water contamination by leachate from the landfill is occurring. The contamination is visible on and below the face of the landfill. GEPA has sampled surface waters bordering the landfill for standard water quality criteria, metals, and organics such as pesticides. GEPA analysis has shown varying levels of all contaminants, this gives rise to the notion that contamination varies with Guam's widely varying levels of precipition. GEPA is in the process of analyzing samples taken from within and immediately outside the face of the landfill. GEPA is also seeking the assistance the U.S. Navy-FENA LAB to analyze independent samples for organics. The results of these analyses will be forthcoming.

Samples taken from the river directly below the landfill on June 21, 1981 exhibited high levels of four pesticides: Lindane = .0002611 mg/l, Endrin = .0004527 mg/l, Methoxychlor = .0021556 mg/l, Toxaphene = .0091156 mg/l. Although subsequent samples failed to exhibit levels above the detectable limits of the analytical equipment we are continuing to closely monitor the site for these compounds. This week three new monitoring sites within the landfill have been established.

The following sections will present verification of specific factors in the Mitre Model with regards to Ground and Surface waters:

1. The depth of Aquifer of concern is greater than 100 ft. The best data available indicates that the landfill lies over a fault between the Marianas limestone of Northern Guam and the Alutom Volcanics of the south. The limestone holds our potable water supplies. The landfill rests on the southern face of a ridge which divides the limestone on the northern side and the volcanics on the southern side. The RCA communications facility in Yona appears to have the only well located in volcanics and be in a relatively close proximity to the landfill. It's across the Pago River valley from the landfill. (The enclosed information from John Mink's Water Resources study should inform you of the nature of volcanic groundwaters aspects. Please see attachment #1). The RCA well is not downgradient from the landfill.

There are two PUAG municipal wells in the vicinity but they drilled in the limestone over the ridge on the northern side of fault from the landfill. These wells are called A-11 and A-12, the depth to water in each well is over 100 ft. (Please see attachment #2).

2. The mean Annual Precipitation is greater than 20 in per year. Average rainfall at all data gathering locations are over 80 inches per year. (Please see attachment #3).

3. The Permeability of the Unsaturated zone is greater 10-3 cm/sec. only if the landfill is over some limestone pockets. If it is completely over volcanics, as we assume, then the permeability is less by a factor of ten, that is .0001 cm/sec. (Please see attachment #1 and #4).

   Therefore the earlier estimate of permeability may have been to high.

   The "bottom-line" on groundwater with respect to the Ordot landfill is that the best data indicates there should be no problems. The landfill is believed to be over highly impermeable volcanic clay soil. The landfill is not over the municipal potable water supply. There are no wells downgradient. The landfill is over 200 ft. above sea level.

4. Containment: There is no liner at the landfill. The landfill surface encourages ponding, and there is no run-on or run-off control. There are no drainage ditches or pipes.

5. 6. and 7. These sections speak of the nature of the wastes disposed of at the Ordot Landfill; Physical State, Persistence/Biodegradability, and Toxicity/Infectousness respectively.

   Since we are unsure of the nature of hazardous waste disposed of at the Ordot Landfill we must assume a worst case basis. No records of materials disposed there have ever been kept. Our monitoring data is weak and incomplete. As stated above GEPA's in the process of analyzing samples from surfaces waters bordering the landfill. (Please refer to attached monitoring data -attachment #5). (Post script: Monitoring data will be forthcoming).

8. The Hazardous Waste Quality rating factor of 1 was used since data is unavailable. As stated above no records are kept as to the nature or quantity of the waste disposed of at the Ordot Landfill.

9. Groundwater use for nearest wells is municipal (PUAG). The wells, A-11 and A-12, are interconnected with the Group VI district. This district serves villages in the central and southern part of the island.

10. Distance of nearest well downgradient is greater than 2,000 ft. A-11, which is the closet PUAG well, is approximately 2,500 ft. away. But we must reiterate our assumption that although A-11 is in the neighborhood of the landfill due to the geohydraulics it is not downgradient.

11. The population served by groundwater within a three mile radius of the Ordot Landfill could be as many as 46,000 according to 1980 U.S. census figures. Although most of the drinking water for southern villages comes from rivers via treatment plants they have been interconnected to the A-series wells, hence the southern villages of Yona, Talofofo, Inarajan, Merizo and Umatac have been included. (Please see well location and population data in attachment #6).

12. Observed Release into Surface Waters has been recognized. (Please refer to Monitoring Data - attachment #5). Both metals and pesticides have been observed in Surface Waters.

13. The use of Surface Waters in the Pago/Lonfit River system is primarily recreational with some limited irragational uses. A number of families consume shrimp, shellfish, fish and other aquatic animals from the system. The river system empties onto the Pago Bay reef. The University of Guam Marine Laboratory as well as recent suburban housing developments are located around Pago Bay.

14. The entire island of Guam especially the reefs are considered Critical Habit according to USEPA per the Mitre Ranking Model. Since the Pago river system flows directly onto the fringing reef of Pago Bay contamination of this Surface Water should be considered particularly critical.

15. The number of Surface Water users with respect to the Pago River and Bay is difficult to determine. Population of nearby villages equal 9,839 persons but many of the islands residents utilize the Pago River/Bay for recreation, especially fishing.

Attachment #1

GROUNDWATER RESOURCES OF GUAM: OCCURRENCE AND DEVELOPMENT

by
John F. Mink

Technical Report No. 1

September 1976

Project Completion Report

for

GUAM GROUNDWATER ASSESSMENT AS OF 1975

OWRT Project No. A-001-Guam, Grant Agreement No. 14-31-0001-5054

Principal Investigators: John F. Mink and James A. Marsh, Jr.

Project Period: June 1, 1975 to September 30, 1976

The research reported herein was funded by the Public Utility Agency of Guam. Funds for the printing of this report were provided by the United States Department of the Interior as authorized under the Water Resources Act of 1964, Public Law 88-379.

TABLE 10

SUMMARY OF PUMPING DATA FOR ACTIVE WELLS

(See column numbers at end of table for column explanations)

1 Well	2 Approx. el. (ft)	3 Bottom el. (ft)	4 h_o(ft) (yr)	5 Origianl Pumping Water Level (Q gpm)	6 1972 Pumping Water Level (Q gpm)	7 1973 Pumping Water Level (Q gpm)	8 $(Cl)_o$ mg/l	9 $(Cl)_{74}$ mg/l	10 Remarks
Togcha									
Tg-1	79	- 32	1.5				31	53	
Tg-2	105	- 25	2.6				31	52	
Tg-3							29	34	
Tg-4							79	51	
Tg-5							77	66	
Tg-6							75	85	
Tg-7							76	92	
Tg-8							75	82	
Tg-9							75	123	
Tg-10							306		
Volcanic Wells									
RCA (Pulantat)	362	+ 2	342	200(20)			20		Alutom fm.
Guam Oil	134	- 66	135				20		Alutom fm.

A similar limestone situation occurs at Camp Dealy just south of Togcha. An exploratory well should be drilled on the 100 ft. elevation terrace near the base of the limestone escarpment at the maximum possible distance from the sea. A few producing wells of 50 gpm each could probably be added to the water supply network.

Volcanic rocks

The exploitability of volcanic rocks for ground water supply is grossly inferior to that of limestone. Typical hydraulic conductivity in the pyroclastic volcanics of southern Guam is less than 0.1 ft/d, about 1000 times less than the typical conductivity in limestone, and consequently well capacities are very low. However, the volcanics are saturated with ground water and a degree of exploitation is possible.

The range of measured hydraulic conductivities in the volcanics is from 0.03 ft/d to 2 ft/d. At the lower end of the range a well penetrating 400 ft. of saturated aquifer would yield only about 20 gpm continuously; at the higher end, wells less than 400 ft. deep could yield 100 to 150 gpm. A well would be an unqualified success if it penetrated rocks with an average permeability of about 0.5 ft/d. The success of wells in lower permeability rocks would have to be measured in terms of local situation, that is, remoteness and need. There is no way to predict volcanic rock permeability, and all wells initially would have to be considered exploratory.

In the valley of the Geus River inland of Merizo an attempt was made to develop ground water in the Facpi member of the Umatac formation. A well drilled to -100 ft. was an utter failure; the permeability of the rock was the lowest encountered on Guam.

APPENDIX A-5

Ground water in the volcanic rocks of southern Guam as determined from stream flow measurements

The volcanic rock formations of southern Guam make very poor aquifers because of their low hydraulic conductivities but nevertheless they carry appreciable volumes of ground water. Only one well in the volcanic rock, that at Guam Oil Refinery producing 100 gpm, can be said to be an economic success. Unfortunately a good log for this well is not available and the nature of the subsurface in the vicinity is therefore unknown. Other volcanic rock wells show very low hydraulic conductivities, practically always less than 1 ft/d. Even so, the RCA well at Pulantat is being used, regardless of the fact that at 20 gpm drawdown is greater than 300 feet, because of the importance of a water supply to the communications station.

Rain that infiltrates the volcanics eventually seeps to stream channels and then flows to the sea. The infiltrate remains in the ground for a long period of time, following tortuous flow paths through poorly permeable tuffaceous shales and sandstones and somewhat more permeable agglomerates to discharge points in stream channels. Water tables are high, in some areas lying within a few feet of the surface. At Pulantat, for instance, the water table is less than 20 feet below the surface, even though ground elevation is about 360 feet.

The exponential flow decay equation may be used to evaluate ground water seepage to stream channels. A channel is treated as a line sink into which uniform seepage per unit length takes place, according to:

(1) $Q = Q_o e^{-at}$

in which, using convenient units, Q is flow in mgd at time t in days; Q_o (mgd) is flow at t = 0; and a is the recession constant.

Seepage flow must not be confused with total runoff; most of the flow in the volcanic streams of the south is direct runoff of rain over the ground surface. Seepage flow can be estimated by analyzing the daily records of flow over the dry season, starting about December 1 and ending in June, and establishing the decay relationship. It is a matter of some judgement to extract from the daily records flows that do not reflect direct surface runoff; ordinarily if the minimum daily flows from one month to the next decrease monotonically, a decay curve can be constructed.

In the analysis, maximum subsurface storage, and therefore maximum seepage, is assumed to occur at the start of December and to decay over a period of 180 days. Table B-6 (Appendix B) gives the initial flow from storage, Q_o, and the flow 6 months later, Q_6, of the major streams in southern Guam for the period 1953 through 1960 (data for 1959 is missing because it wasn't available when the analysis was made). From this data, the recession constant, a, the subsurface volume tributary to the stream channel, and the subsurface volume which drains to the stream over the period of 180 days can be computed. These parameters in some measure define the characteristics of ground water occurrence in the volcanic rocks.

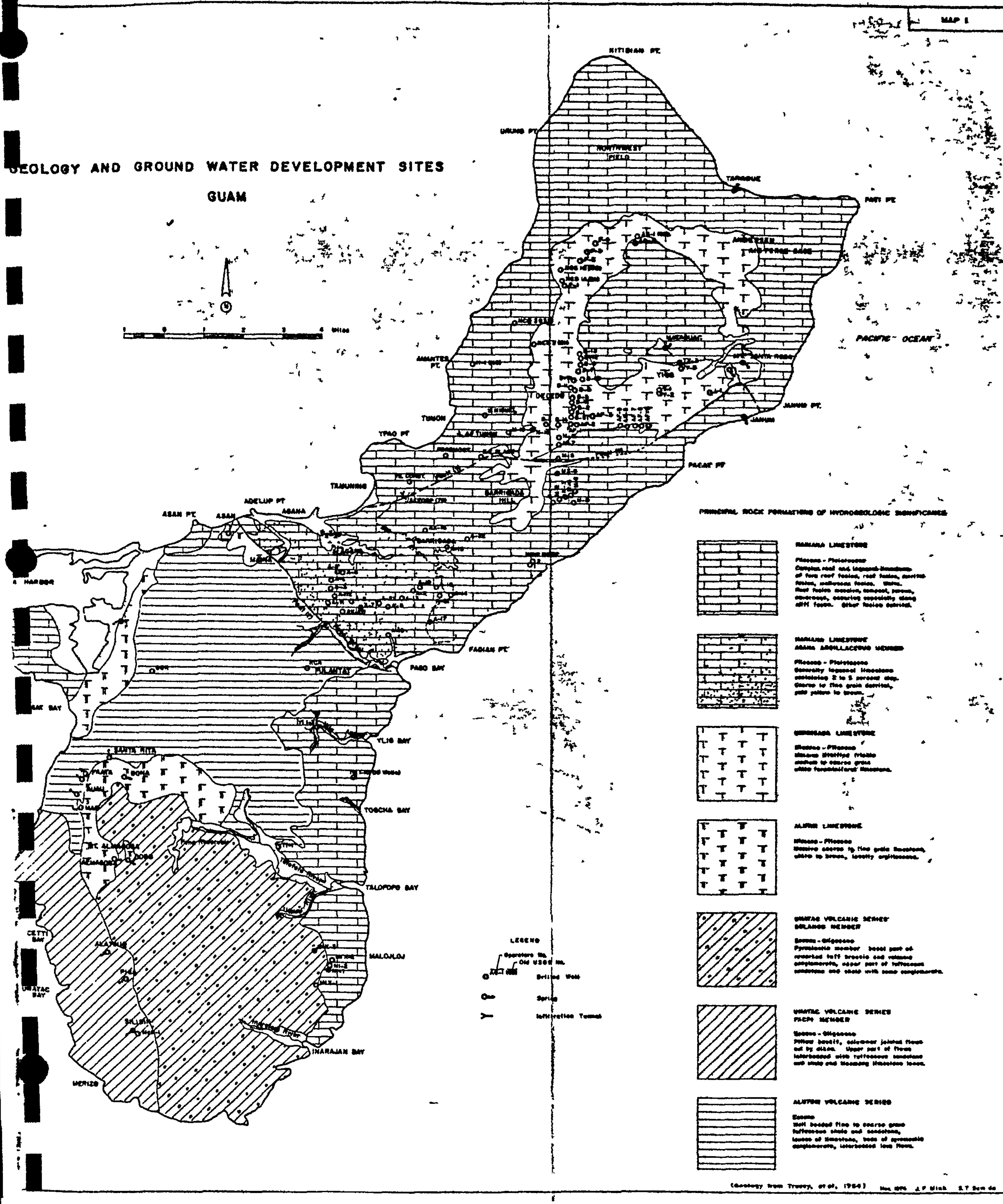
Table B-7 (Appendix B) gives a summary of the runoff characteristics of the major streams of southern Guam, emphasizing the ground water contribution. Streams are listed by type of rock formation which they drain. The Ugum, Inarajan and Tinaga (formerly called Paulilue by the USGS) rivers chiefly drain the Bolanos pyroclastic member of the Umatac formation; this member consists of tuffaceous shale, sandstone and agglomerate. The Umatac River chiefly drains the Facpi volcanic member of the Umatac formation, consisting of pillow basalts overlain by tuffaceous shale and sandstone with lenses of limestone. The Ylig and Pago Rivers drain the Alutom volcanic formation, which is predominantly formed of tuffaceous shale and sandstone. The recession constant, a, of the streams reflects the subsurface geology of the drainage basins in that it is directly proportional to hydraulic conductivity and aquifer thickness, and inversely proportional to effective porosity.

The data in table B-7 clearly shows that ground water storage in the Bolanos member is far greater per unit drainage area than in either the Facpi member of the same formation or in the Alutom formation. The Ugum drainage basin has especially large ground water storage. The low unit storage for the Tinaga River basin probably results from pirating of subsurface water within its geographic boundaries by the more deeply incised Ugum and Inarajan Rivers. The Ugum may also pirate some of the subsurface flow of the upper drainage region of the Inarajan River. With respect to ground water the basins of the three rivers should be treated as a single regional unit, the subsurface drainage from which comes nearly exclusively from the Bolanos member.

Calculations suggest that the total volume of ground water availabe for drainage to the three Bolanos basins is 152 mg/mi^2 at the start of the dry season, of which 118 mg/mi^2 actually drains to the streams during the 6 months period. On the other hand, the Alutom formation of the Ylig and Pago basins carries considerably smaller ground water storage per unit drainage area, only about 60 - 65 mg/mi^2, less than half that in the Bolanos member. Also the recession constants for the Ylig and Pago Rivers are nearly twice as great as those for Bolanos streams, reflecting rapid drainage. Still another significant difference between Bolanos and Alutom streams is the ratio of runoff to rainfall, which is about .57 for the Bolanos and .65 for the Alutom, denoting higher total yields from the latter formation.

Because hydraulic conductivities of the volcanic formations are very low, in the normal case producing wells would have to be very deep to provide even small quantities of water. It is improbable that the economics of deep wells equipped with small capacity pumps would justify widespread development of ground water from the volcanics for some time. Local requirements, however, might justify the expense. In locations where volcanic rocks encase limestone lenses, such as at Malolo and Talofofo, immediate exploitation of the limestone aquifers would be appropriate.

Table B-7 also provides important information with respect to surface water exploitation. As an example, for the Ugum River the total ground water seepage over the 180 day dry period is 1109 mg, which averages to 6.16 mgd. This does not include the direct surface runoff component of the rainfall. In effect, the volcanic rocks are porous media reservoirs whose slow seepage rates could be exploited in designing surface reservoirs. For this purpose, the Ugum River basin has the best characteristics, while the Ylig and Pago basins have the poorest. The Ugum River would require a smaller surface reservoir per unit flow than the Ylig or Pago Rivers because substantially more of its total flow consists of ground water seepage. For the Ugum River, of the total average flow of 19 mgd, 6.16 mgd (32.4%) consists of ground water, while of the total average flow of 16.8 mgd for the Pago River, 1.91 mgd (11.4%) consists of ground water.



GEOLOGY AND GROUND WATER DEVELOPMENT SITES
GUAM
MAP 1
RITIDIAN PT.
NORTHWEST FIELD
TARAGUE
PATI PT.
PACIFIC OCEAN
JANUM PT.
PAGAT PT.
AMANTES PT.
DEDEDO
TUMON
YPAO PT.
TAMUNING
ADELUP PT.
AGANA
ASAN PT.
ASAN
BARRIGADA HILL
FADIAN PT.
PAGO BAY
YLIG BAY
TOGCHA BAY
TALOFOFO BAY
MALOJLOJ
INARAJAN BAY
MERIZO
UMATAC BAY
CETTI BAY
SANTA RITA
PRINCIPAL ROCK FORMATIONS OF HYDROGEOLOGIC SIGNIFICANCE
MARIANA LIMESTONE
Pliocene - Pleistocene
MARIANA LIMESTONE
AGANA ARGILLACEOUS MEMBER
Pliocene - Pleistocene
ALIFAN LIMESTONE
UMATAC VOLCANIC SERIES
FACPI MEMBER
ALUTOM VOLCANIC SERIES
LEGEND
Drilled Well
Spring
Infiltration Tunnel
(Geology from Tracey, et al, 1964)

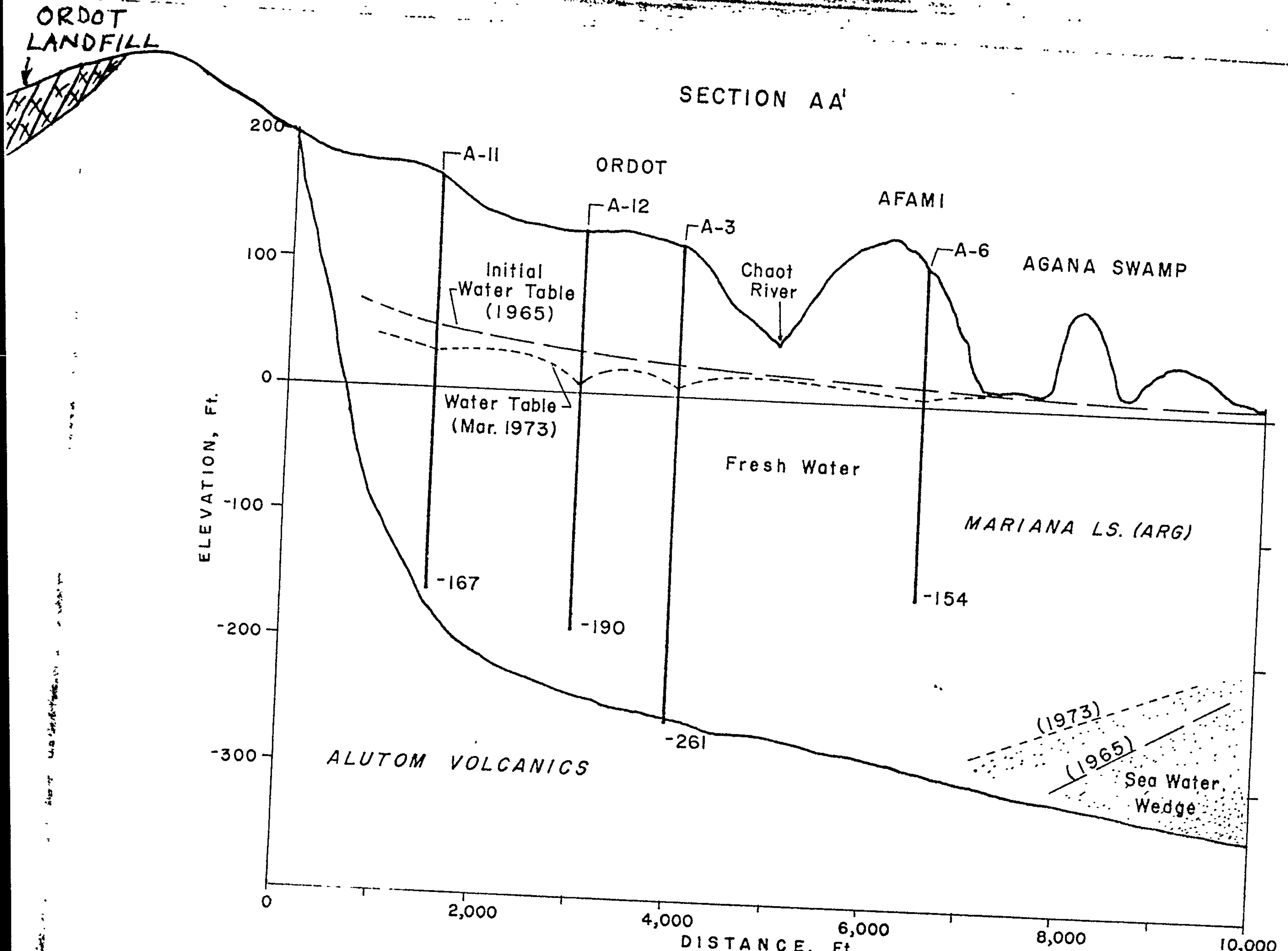
Attachment #2

TABLE 10

SUMMARY OF PUMPING DATA FOR ACTIVE WELLS

(See column numbers at end of table for column explanations)

1	2	3	4	5	6	7	8	9	10
Well	Approx. el. (ft)	Bottom el. (ft)	h_o (ft) (yr)	Original Pumping Water Level (Q gpm)	1972 Pumping Water Level (Q gpm)	1973 Pumping Water Level (Q gpm)	$(Cl)_o$ mg/l	$(Cl)_{74}$ mg/l	Remarks
A-1	68	-152	19(65)	102(200)			20	18	volc. -252
A-2	118	- 54	12(65)	129(210)	136(179)	145	16	16	
A-3	127	-262	22(66)	204(273)	150(194)	172	16	16	volc. -256
A-4	140	-160	6.2(66)	145(300)	145(171)	148(171)	17	17	
A-5	146	-172	9.1(66)	142(214)	142(171)	144	16	16	volc. -186(?)
A-6	152	-154	10(67)	143(300)	148(211)	150	16	16	
A-7	136	- 50	10(67)	146(200)	150	155	16	16	
A-8	124	-177	15(67)	143(207)	157(200)	171	16	18	
A-9	187	- 50	6.6(67)	182(226)	187		95	152	
A-10	191	- 25	6.5(67)	185(218)			80	225	
A-11	178	-167	47(68)	320(179)	195(146)	280(133)	15	17	volc. -174
A-12	138	-190	31(68)	142(214)	155(145)	231(133)	15	15	
A-13	131	-199	7.0(68)	141(200)	148(197)	149	60	276	
A-14	200	- 60					110	218	Poor record
A-15	198	- 52	(73)	206(225)			105	141	Poor record
A-16	195	- 40	(73)	210(200)				527	Poor record



ORDOT LANDFILL
SECTION AA'
ORDOT
AFAMI
AGANA SWAMP
A-11
A-12
A-3
A-6
Chaot River
Initial Water Table (1965)
Water Table (Mar. 1973)
Fresh Water
MARIANA LS. (ARG)
ALUTOM VOLCANICS
-167
-190
-261
-154
(1973)
(1965)
Sea Water Wedge
ELEVATION, Ft.
200
100
0
-100
-200
-300
DISTANCE, Ft.
0
2,000
4,000
6,000
8,000
10,000

FIG. II

144

Attachment #3

TABLE 3-1

AVERAGE ANNUAL RAINFALL BY LOCATION

Location	Years of Record	Average Annual Rainfall (inches)
Weather Bureau	1957-1974	100.21
Anderson Air Force Base	1952-1974	94.76
Umatac	1950-1974	98.98
Fena Filter Plant	1951-1974	96.32
Ylig Filter Plant	1953-1974	98.73
Naval Air Station	1953-1974	83.63
Nimitz Hill EWC	1945-1974	95.40
Almagosa Spring	1947-1968	111.79
Naval Communications Station	1947-1959	88.55
Pago River	1947-1967	90.78
Fena Dam	1950-1969	98.70
Inarajan	1947-1966	85.48
Mt. Tenjo Station	1947-1956	81.78
Tamuning	1951-1962	85.97
Adelup Station	1947-1957	81.85

Source: U.S. Geological Survey

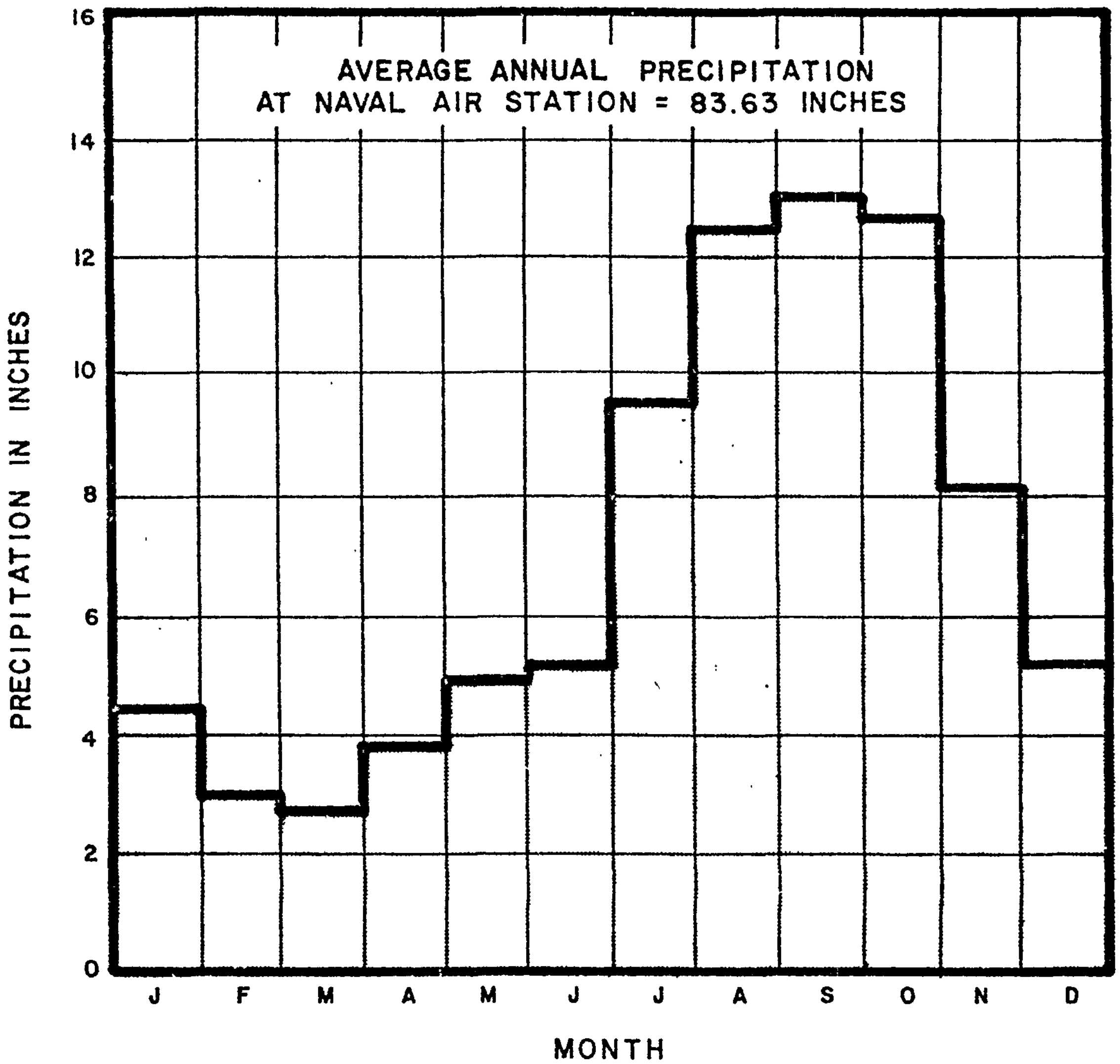


FIGURE 3-4
PRECIPITATION BY MONTH

4.

Attachment #4

NORTHERN GUAM LENS STUDY

A PROGRESS REPORT

October, 1980

Water Resources Research Center

University of Guam

Mangilao, Guam 96913

The equations of course assume that the well screens exist throughout the depth of the fresh water lens. In the field, the well is dug to a depth a few feet below the phreatic surface. The well screen is generally very short in comparison with the thickness of the freshwater lens.

4. Data Requirements of Models.

Modeling saltwater intrusion into any aquifer, using any type of model, can only be accomplished if the geometric and hydraulic characteristics of the aquifer are known. These characteristics include the depth to basement rock, the elevation of the ground surface, the porosity of the aquifer, and the permeability of the aquifer. The depth to basement rock in Guam's aquifer has been obtained by geophysical methods in a separate task of this project. The results of the elevation of the basement for a node placed anywhere in the aquifer will be known. The elevation of the ground surface will be obtained from the USGS office in Guam.

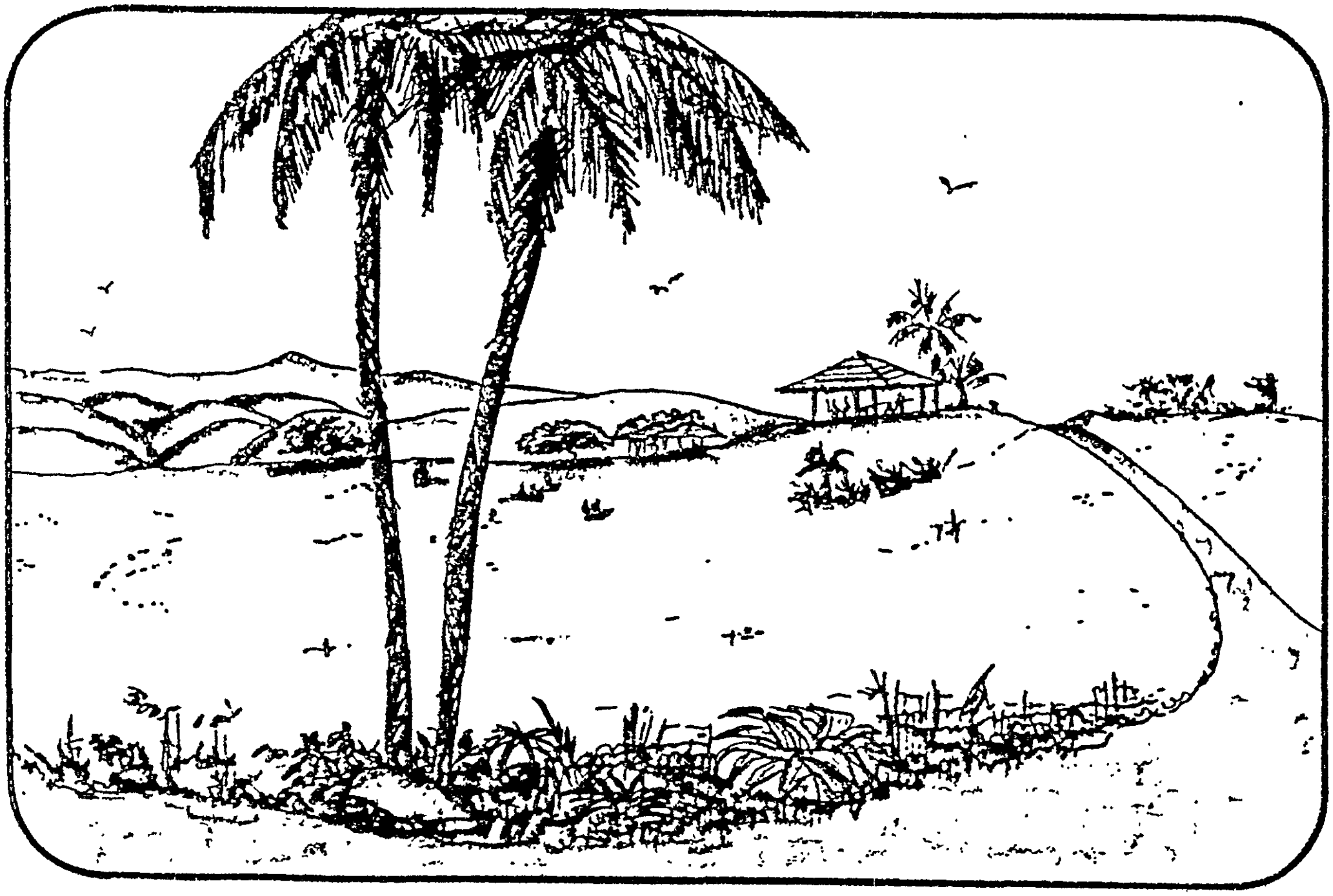
The porosity and permeability of the rock can be expected to vary considerably over the aquifer. In the past, scattered pump tests have been conducted and local values of porosity and permeability have been obtained (6). The values of porosity are about 10% and permeability ranges from 20 to 200 ft/day. On a regional basis, the porosity does not change much from 10%; however, from an analysis of the hydrologic budget and also tidal fluctuations, a regional value of permeability between 1000 and 2000 ft/day was obtained.

The values of porosity and permeability mentioned in the previous paragraph represent the best information we have till now. They will also be obtained during the calibration of the model. These two parameters are varied in the model till satisfactory agreement is obtained between measured data and the results of the computer program.

5. Calibration and Verification Data.

Before any model can be used for management purposes, the model should be calibrated and verified using field data. The model should be able to reproduce satisfactorily the main features of the phenomenon under study. In this particular case, the model should be able to reproduce the elevations of the phreatic surface and the interface, as the aquifer is subject to varying inputs. Measured data on the elevation of the interface are lacking and so the model will be calibrated and verified using data on the elevation of the free surface. The major input that changes the elevation of the free surface is the variation of the

Guam Sanitary Landfill Plan



Final Report

June 1981

GMP ASSOCIATES, INC.

6. ~~The hydraulic characteristics of the soil cover and compacted solid waste are uniform in all directions.~~

7. ~~The depth of the landfill will be much less than its horizontal extent. Thus, all water movement will be vertically downward.~~

C. Prediction of Leachate Quantity and Timing

Water balance calculations for Ordot consider two cases, namely (1) mean monthly precipitation values determined over a ten-year period, and (2) monthly precipitation for a year in which there were heavy storms - 1976. Results are shown in Figures A-6, and A-7 for cases (1) and (2), respectively.

The results predict that for case (1), about 16 inches (400 mm) of the 98 inches (2500 mm) of annual rainfall will percolate through the cover soil, and eventually account for leachate generation on the site. Case (1) is characterized by one wet season and one dry season during each one year cycle.

No leachate is anticipated to be generated during the months from January to July and in December. For case (2), a percolation of 29 inches (750 mm) per year is estimated. Cases (1) and (2) demonstrate possible extremes for

FIGURE A-6

WATER BALANCE FOR ORDOT SLF BASED ON 10 YR. AVG. RAINFALL DATA

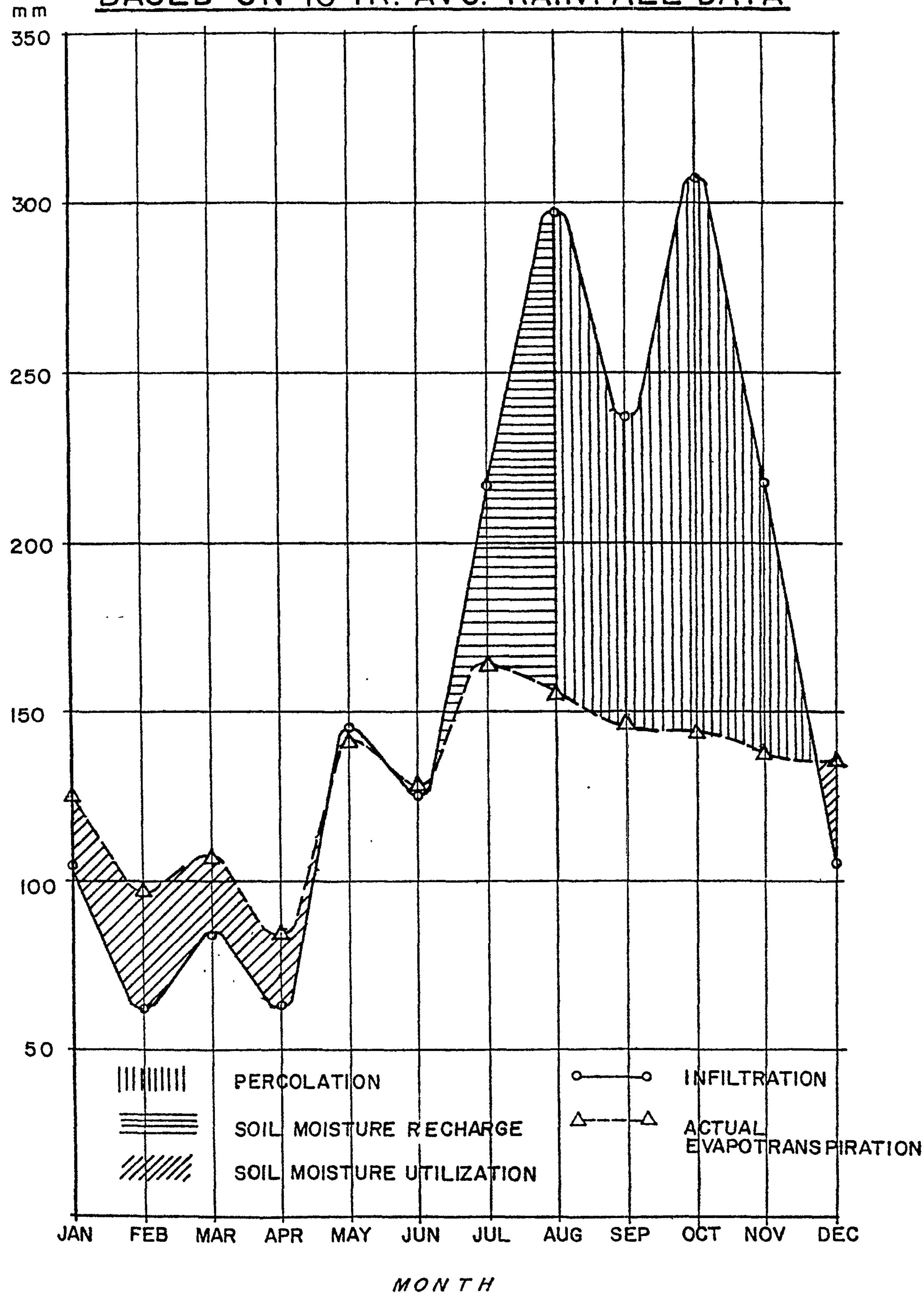
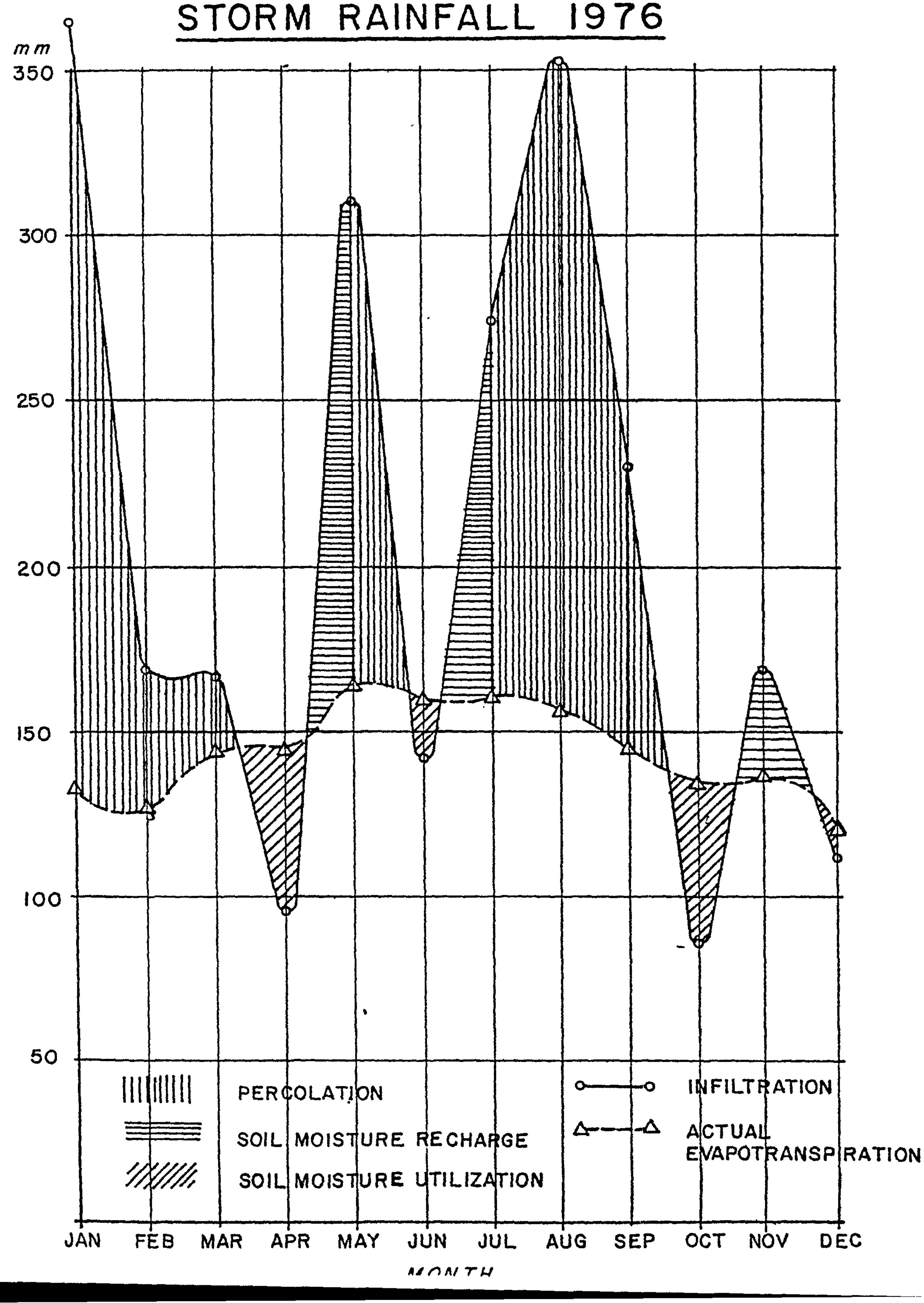


FIGURE A-7

WATER BALANCE FOR ORDOT SLF
STORM RAINFALL 1976



leachate generation rates at Ordot. They also reflect the fluctuating nature of percolation, which in turn causes variations in leachate generation over time.

Having computed the amount of water that will percolate through the cover soil, an analysis of the water travel pattern through the solid waste can now be performed to determine the magnitude and timing of leachate generation.

Figure A-8 shows the relationship between annual percolation amounts and time of first appearance of leachate for various landfill depths. Figure A-9 shows the relationship betwen annual percolation amounts and leachate quantities for various size landfills. These two figures are drawn to larger scales than those used by Fenn (1975) so that greater percolation quantities can be accommodated. These figures are used for predicting timing and quantities of leachate production at Ordot for Phases I and II.

If Ordot SLF were to be terminated at the end of Phase I (6 years), its final cover top elevation would be 230 feet above sea level. If operations were terminated at the end of Phase II (cumulative 15 years for Phases I & II) the top elevation would be 300 feet.

B. Surface Water

Table A-7 presents the results of recent surface water monitoring performed by the Guam Environmental Protection Agency (GEPA), which may be pertinent to the Ordot landfill. Sampling points for this data were in the Lonfit River upstream and downstream of the Ordot landfill. The U.S. Geological Survey (USGS) has been collecting water quality and stream flow data from a Pago River gaging station 0.8 miles south of Ordot since May 1978. Table A-8 shows this data for the period from October 1978 to September 1979.

The data can serve as base-line data for surface water quality in the vicinity of the landfill.

C. Ground Water

There are seven wells within one-half mile to 1-1/2 miles northwest of the Ordot landfill site. The closest wells are A-11 and A-12 shown in Figure 3. Unfortunately, there is only limited water quality data from these wells. In seeking base-line ground water quality data, the Ghura-Dededo deep monitoring well (Latitude $13^{\circ}31'20''$, Longitude $144^{\circ}50'54''$) in the northern district of Guam, appears to be only source for such comprehensive information. Since that well is in a different geological formation than Ordot, the data are not considered helpful in relation to Ordot Sanitary Landfill. Limited water quality data are available for wells A-11 and A-12 at the Guam office of the U.S. Geological Survey.

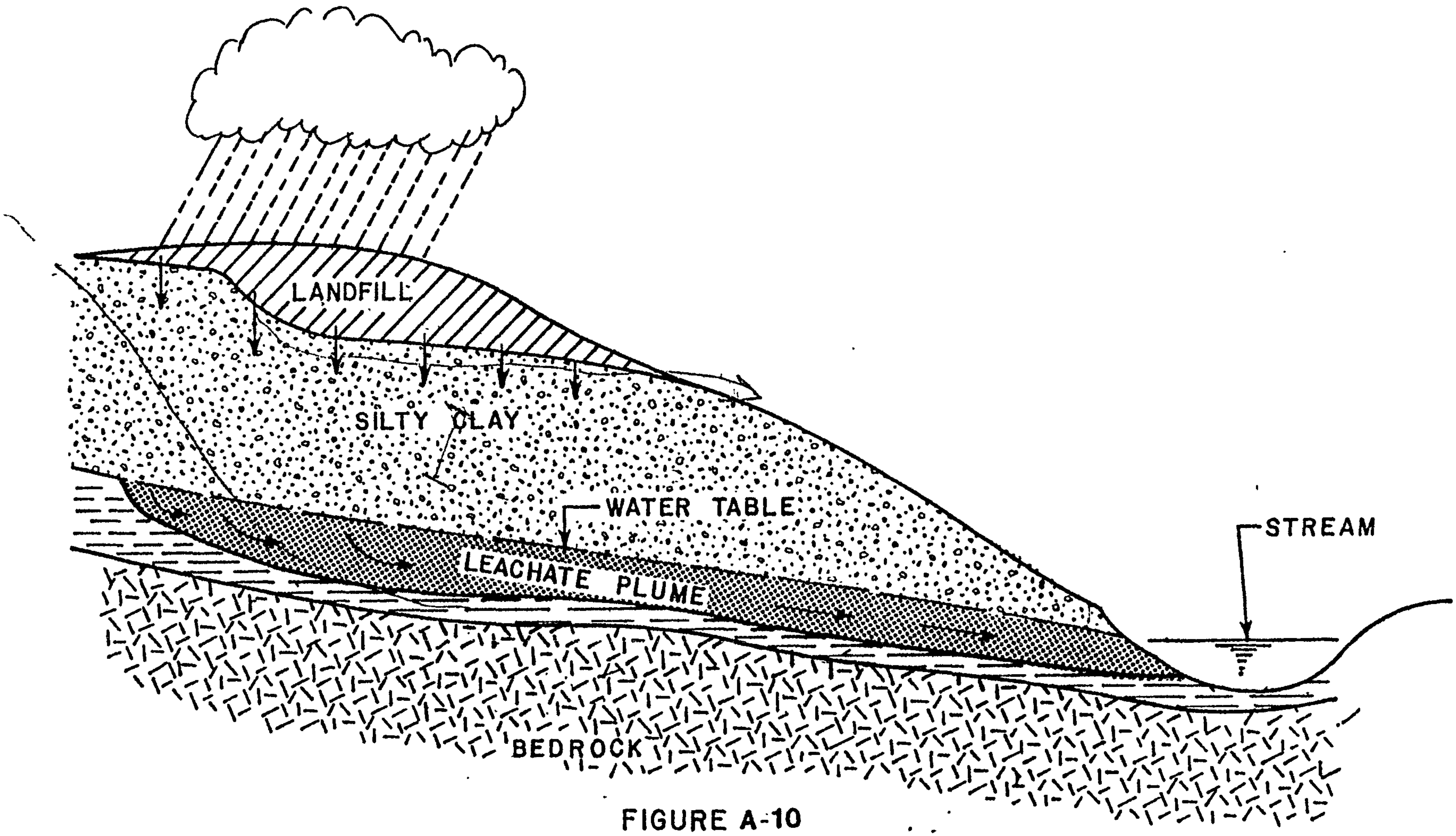


FIGURE A-10

ASSUMED CROSS-SECTION

ORDOT LANDFILL

Attachment #5

Monitoring Data:

Laboratory Analysis of Surface Waters is incomplete and will be forthcoming.

Attachment #6

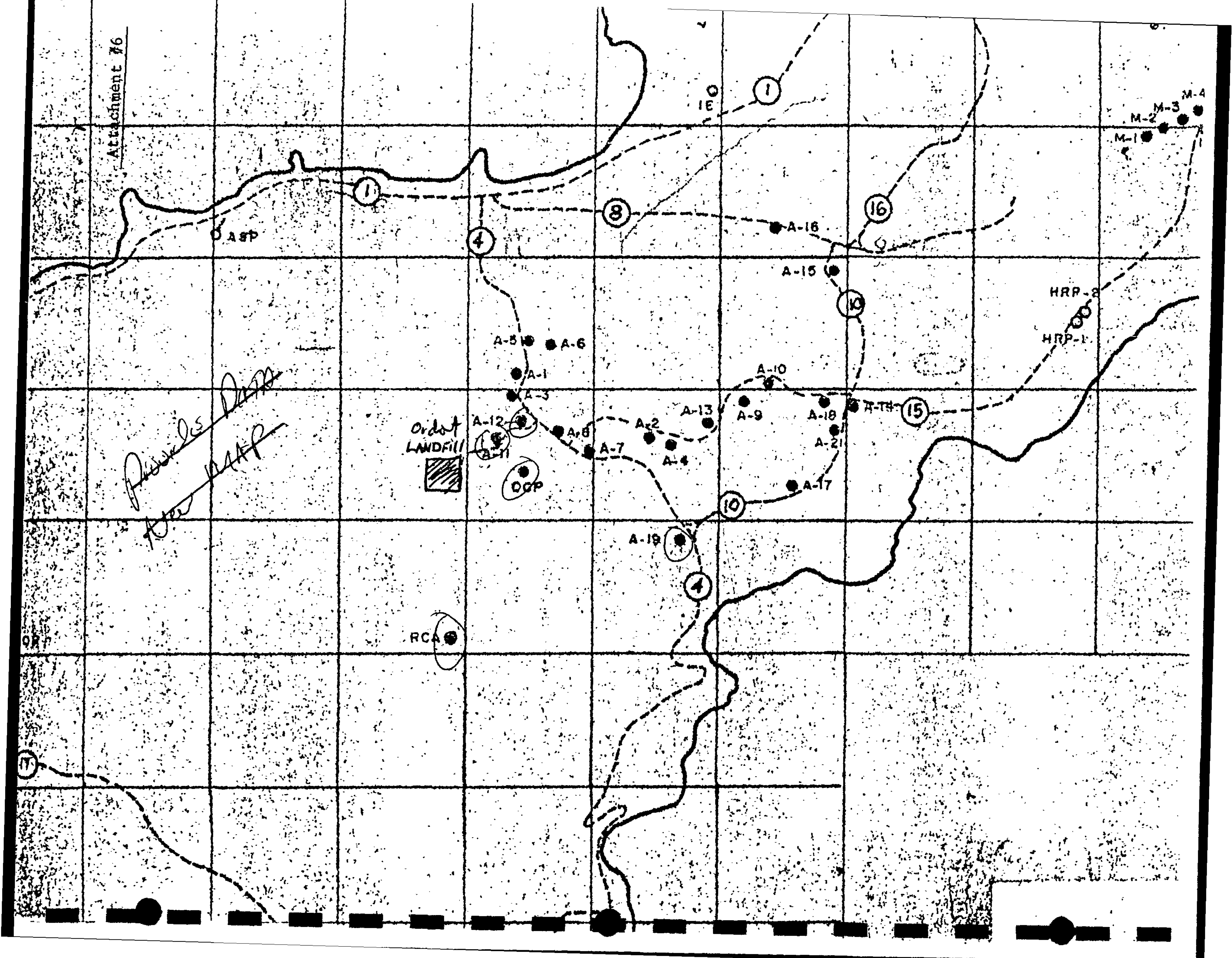


Table 1. Population and Housi- - Unit Counts for Guam by Election Districts: 1980 and 1970

[Counts re... areas as delineated at each census. Information on boundary changes wi... own in the PC80-1-A report for this area. For meaning of symbols, see text]

Jim
Bob

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Guam Election Districts	Population 1980 (preliminary)	Population 1970	Housing units 1980 (preliminary)	Housing units 1970
Guam	105 821	84 996	28 217	16 680
Agana district	881	2 119	376	515
Agana heights district	3 294	3 156	979	657
Agat district	3 979	4 308	990	819
Asan district	2 024	2 629	591	581
Barrigada district	7 762	6 356	1 922	1 307
Chalan Pago-Ordot district	3 135	2 931	736	525
Dededo district	23 646	10 780	5 549	2 295
Inarajan district	2 062	1 897	455	321
Mangilao district	4 810	3 228	2 063	740
Merizo district	1 653	1 529	403	271
Mongmong-Toto-Maite district	5 230	6 057	1 483	895
Piti district	1 518	1 234	502	259
Santa Rita district	10 408	8 109	2 252	1 617
Sinajana district	2 471	3 506	616	680
Talofofo district	2 016	1 935	447	350
Tamuning district	13 537	10 218	4 733	2 206
Umatac district	732	813	146	120
Yigo district	10 435	11 542	2 891	2 056
Yona district	4 223	2 599	1 031	467

Table 2. Population and Housing Unit Counts for Places: 1980 and 1970

[Table omitted because the area has no places other than census designated places. They will be shown in the PHC80 V and appropriate final reports.]

Bob > Please xerox copies for
John, Christi & Jim

SOURCE: LAND USE PLAN-GUAM, 1977-2000
BUREAU OF PLANNING,
GOVERNMENT OF GUAM

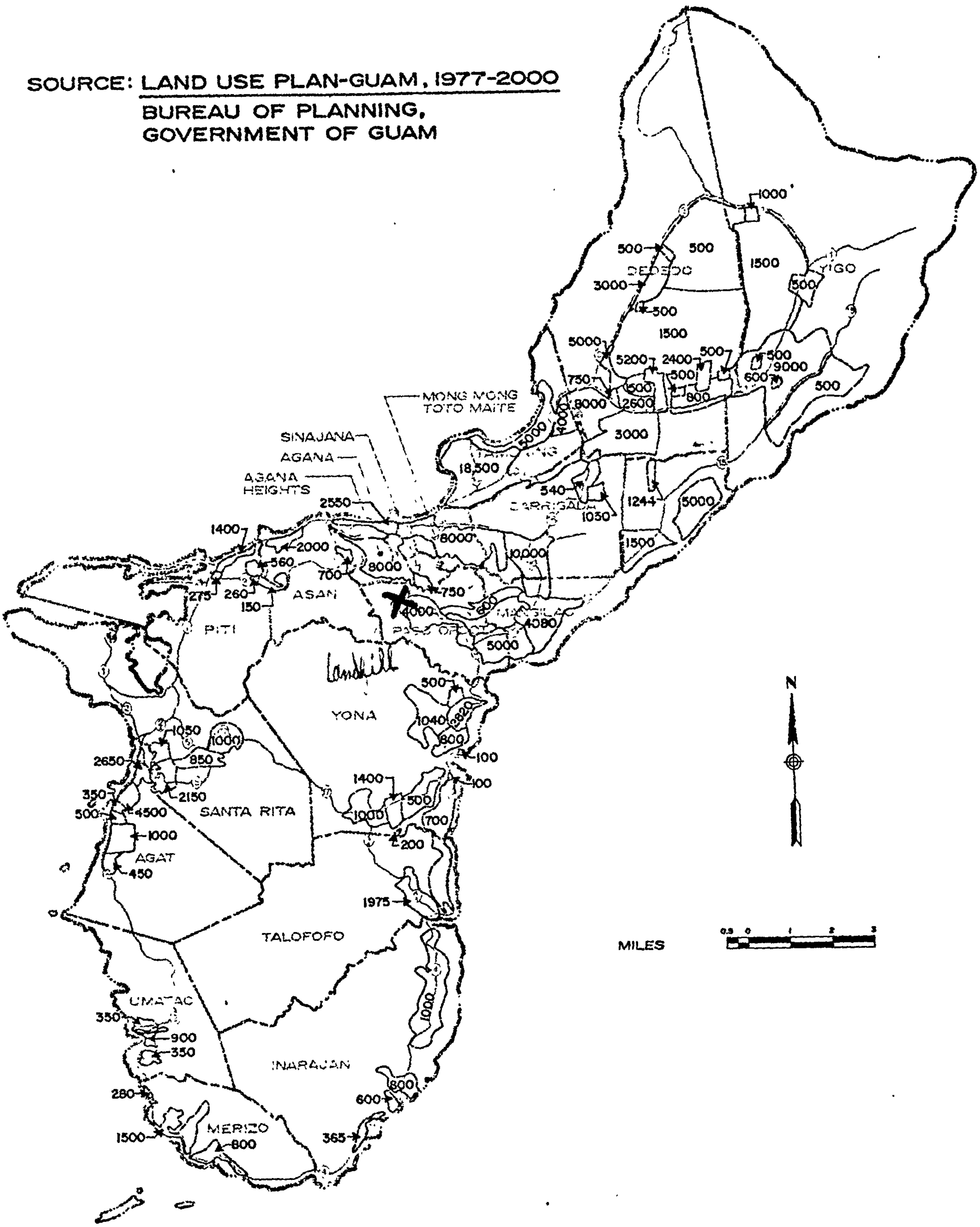

FIGURE 3-8
CIVILIAN POPULATION PROJECTIONS
FOR THE YEAR 2000